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Response of Organic and Inorganic Source of Nutrient on Growth, Uptake and Quality of Mustard (*Brassica juncea* L.)

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ABSTRACT: The effect of vermicompost and nutrients with the bio-fertilisers on the quality, growth, and uptake of nutrients by mustard (*Brassica juncea* L.) was investigated in a field trial at the Agronomy Research Farm of Rashtriya Kisan College, Shamli (U.P.), during the *rabi* season 2019–20. A RBD design with three replications was used to set up the experimental unit. Use of treatments during research work of mustard var. *Laxmi* consisting of nine treatment combinations, *viz*., control (T_0), 75 % RDF (T_1), 100 % RDF (T_2), vermicompost @ 2 t ha^{-1} (T_3), FYM 10 t ha^{-1} + azotobacter (T_4), 75 % RDF + vermicompost (2 t ha^{-1}) + Azotobacter (T_5), 100 % RDF + vermicompost (2 t ha^{-1}) + azotobacter (T_6), 75 percent RDF + FYM 10 t ha^{-1} + Azotobacter (T_7) and 100 % RDF + FYM 10 t ha^{-1} + azotobacter (T_8). The application of 100 % RDF + vermicompost (2 t ha^{-1}) + azotobacter (T_6) was found to maximise plant height, dry matter accumulation, number of branches plant^{-1}, nitrogen, phosphorus, potassium content and uptake in seed and stover, oil content, and oil yield and remaining treatment T_2, T_5, T_7, and T_8 at par. The soil microflora derives its energy from organic matter, and the amount of organic carbon in the soil is regarded as a measure of its health. INM is a flexible approach that aims to maximise farmers' profits while minimising the use of chemical nutrient sources.

Keywords: Mustard, vermicompost, azotobacter, organic matter.

INTRODUCTION

In Indian agriculture, oilseeds hold a distinguished position next to cereals. The most profitable crops in India are oilseeds because of their high adaptability to various agro-climatic conditions (Shekhawat *et al*., 2012). Mustard and rapeseed are important oilseed crops grown in the Indian subcontinent, particularly during the winter season, and account for 27% of edible oil production (Khare *et al.*, 2023). It is grown in the Indian states of Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh, and Gujarat. This crop is the main edible oilseed crop in India, producing almost one-third of the nation's oil. Indian mustard is grown as a rainfed crop on leftover soil in the state of Uttar Pradesh. With a cultivation area of 0.70 Mha, 0.99 Mt of production, and a productivity of 1412 kg ha^{-1}, this plant successfully retains moisture thanks to its deep root system (Anonymous, 2021). Although honeybees may contribute to a small (2–15 percent) amount of cross-pollination in the case of mustard, the crop is largely self-pollinated. More than 13 percent of the world's edible oil production comes from it because the larger area planted with oilseed crops like rapeseed, mustard, sunflower, and soybeans or by maximum production per unit area, the smaller gap between domestic consumption and productivity of edible oils. The only way to increase productivity in the context of constrained resource availability is to produce an extra amount of oilseed (Chandan *et al*., 2019).

Nutrient management is one of the most crucial agronomic factors that influences the productivity of mustard. But the haphazard use of inorganic fertiliser accelerated soil deterioration. Lack of high-yielding varieties, biotic, abiotic stress-resistant varieties, cultivation with unbalanced nutrient use in rainfed area, and poor knowledge of morden technology these factors are causing low yields of rapeseed mustard in India (Thaneshwar *et al*., 2017). The low productivity of mustard crops is thought to be due to continuous reductions in soil fertility caused by imbalanced fertilisation. The situation has resulted in demands for crop nutrition strategies to be implemented (Dhruw *et al*., 2017). Until recently, primary nutrient application has been the primary focus of Indian farmers. This method disregards crop demands for secondary and micronutrients, which are assumed to be fulfilled by soil storage (Pramanick *et al.*, 2023). INM is the use of soil fertility management practises to maximise fertilizer and organic sources use efficiency in increasing crop production (Sanginga and Woomer 2009). According to Tomar *et al.* (2019), the application of organic manure and chemical fertilisers increases the mineral content of the soil, the field's capacity to hold water, and the uptake of nutrients. In addition, a number of other changes, including root growth, vegetative growth, and nitrogen fixation, increase crop yield.

Erucic acid, linoleic acid, and oleic acid are present in the seeds in amounts of 38–57%, 5–13%, and 27%, respectively (Dubey *et al.*, 2022). Sulphur is a crucial nutrient for the production of oilseeds because it directly contributes to the formation of oil compounds in plants. When a crop lacks S, it not only yields little but also has little oil in the seed (Kumar *et al*., 2019).

During the *rabi* season 2019–20, an experimental unit was conducted at the Agronomy Research Farm of Rashtriya Kisan College, Shamli (U.P.) to examine the effect of INM on growth, nutrient uptake and quality. Geographically, the town is situated at 29.450 N latitude, 77.320 E longitude, and 248 M above MSL. The experimental unit of soil texture is silt loam with 1.38 Mg m^{-3} BD, 2.60 Mg m^{-3} PD, 46.93% porosity, 0.32 % organic carbon, EC (0.33 ds m^{-1}), 180.40 kg ha^{-1} available N, 18.40 kg ha^{-1} P, 290.12 kg ha^{-1} K, and pH 7.90. The treatment combinations of nine treatment consisting viz., control (T_0), 75% RDF (T_1), 100 % RDF (T_2), vermicompost @ 2 t ha^{-1} (T_3), FYM 10 t ha^{-1} + azotobacter (T_4), 75 % RDF + vermicompost (2 t ha^{-1}) + azotobacter (T_5), 100 % RDF + vermicompost (2 t ha^{-1}) + azotobacter (T_6), 75 % RDF + FYM 10 t ha^{-1} + azotobacter (T_7) and 100 % RDF + FYM 10 t ha^{-1} + azotobacter (T_8). The variety of mustard *Laxmi is* sowing. Before sowing, apply FYM and vermicompost in the field according to the treatments. Prior to sowing, a complete dose of P, K and half of N was applied as a basal amount using urea and DAP. In two equal splitting of urea applied at 25 and 40 DAS. Application of bio fertilizers required the boiling and cooling of 30 g of jaggery in 1.5 lit of water with the addition of 50 g of azotobacter culture. To inoculate the seeds with azotobacter, the necessary amount of seed was thoroughly combined with the culture paste, and the seeds were then left to dry in the shade. To prevent diseases transmitted through seeds, carbendazim (2 g kg^{-1} seed) was applied to mustard seeds of the *Laxmi* variety. On November 5, 2019 sowing of crop with "kera" method. The spacing from row to row is 30 cm and from plant to plant is 15 cm. At 25 and 35 DAS, the thinning and weeding were carried out manually. Depending on the water requirements of crop, irrigation is applied by the check basin method. Harvesting of crop at March 20, 2020, when it reached physiological maturity. Recording of various data, including plant population, plant height, dry matter, and branch count, according to a schedule. The uptake of N, P, and K by seed and stover was calculated using the formula given below. The oil content of mustard seeds was extracted by petroleum ether (60–80 °C) soxhlet apparatus. Oil yield was calculated by using the formula given below.

$$\text{N, P, K, S. uptake (kg ha}^{-1}) = \frac{\text{Nutrient content (\%) in seed/stover} \times \text{Seed/stover yield (kg ha}^{-1})}{100}$$

$$\text{Oil yield (kg ha}^{-1}) = \frac{\text{Oil content in seed (\%)} \times \text{Grain yield (kg ha}^{-1})}{100}$$

The method used for statically analysis of variance of experimental data related to growth attributes, nutrient content, uptake and quality of mustard by Fisher (1950).

RESULT AND DISCUSSION

A. Impact of INM on growth attributes

The application of 100% RDF + vermicompost (2 t ha^{-1}) + azotobacter significantly improved growth attributes, including height of plant (91.21 cm at 60 DAS and 121.78 cm at harvest), number of branches (6.56 at harvest) and dry matter (95.58 g m^{-2} at 60 DAS, 180.97 g m^{-2} at 90 DAS and 217.76 g m^{-2} at harvest) (Tables 1 and 2). Because of the direct addition of fertiliser, the major nutrients (N, P, and K) are now more readily available, which may account for the increased height, dry matter accumulation, and branches of the plant. One of the most important nutrients for plants, nitrogen, is necessary for bigger, more numerous cells, which promote better growth in plant height, dry matter accumulation and number of branches. As the second most important nutrient for plant growth and development, phosphorus is crucial for the transfer and conservation of energy during metabolic activity in living cells, including the conversion of bioenergy. Application of phosphorus to low phosphorus soils may have improved the availability of phosphate, leading to more uptake, which in turn led to increased plant growth. It is well known that exchangeable potassium aids in protein synthesis, chlorophyll formation, and increasing stress resistance, all of which may improve the growth and development of plants. With the application of vermicompost, plants may have received more nutrients for a longer period during the vegetative to reproductive phases, which may account for the increase in height, dry matter, and branches of the plant. Due to these bacteria's capacity for N-fixation, the beneficial impact of bacterial inoculation may be attributed to an increase in N supply in inoculated plots. The findings of the current study are very similar to those of Dhruw *et al*. (2017), Kumar *et al*. (2017), Saini *et al*. (2017), Kumar *et al*. (2018a), Murali *et al*. (2018), Singh *et al*. (2018), Yadav *et al*. (2018), Pooniyan *et al*. (2022), Singh *et al*. (2023), Sharma *et al*. (2023) and Gupta *et al*. (2023) in the mustard crop.

B. Impact of INM on nutrient content and uptake

A positive effect on the nutrient content and uptake of mustard was observed by the application of inorganic fertilizer with organic manure and bio-fertilizer. The application of 100 percent RDF + vermicompost (2 t ha^{-1}) + azotobacter (T6) resulted in the highest levels of nitrogen (3.14 and 0.594 percent), phosphorous (0.530 and 0.295 percent), and potassium (0.615 and 1.47 percent) content and N, P and K uptake in seed and stover, 57.43 and 21.5 kg ha^{-1}, 9.70 and 10.80 kg ha^{-1}, and 11.23 and 53.80 kg ha^{-1}, respectively (Table 4).

Table 1: Effect of integrated nutrient management on plant population m^{-1} row length, plant height and branches $plant^{-1}$ of mustard (*Brassica juncea* L.).

Treatment	Plant population m^{-1} row length		plant height (cm)		Branches $plant^{-1}$ at harvest
	At 30 DAS	At harvest DAS	At 60 DAS	At harvest	
T_0 – Control	9.04	8.52	58.80	134.46	4.34
T_1 - 75% RDF	9.30	8.78	73.38	162.44	5.24
T_2 - 100% RDF	9.26	8.74	85.88	185.94	6.33
T_3 - Vermicompost (2 t ha^{-1})	9.35	8.93	72.22	160.78	5.13
T_4 - FYM 10 t ha^{-1} + *Azotobacter*	9.25	8.83	70.96	158.94	5.03
T_5 - 75% RDF + Vermicompost (2 t ha^{-1}) + *Azotobacter*	9.57	9.14	88.79	189.12	6.45
T_6 - 100% RDF + Vermicompost (2 t ha^{-1}) + *Azotobacter*	9.65	9.34	91.21	193.78	6.56
T_7 - 75% RDF + FYM 10 t ha^{-1} + *Azotobacter*	9.85	9.53	87.24	187.35	6.41
T_8 - 100% RDF + FYM 10 t ha^{-1} + *Azotobacter*	9.76	9.43	89.75	191.78	6.51
SEm$\pm$	0.50	0.49	3.86	7.33	0.25
CD (P = 0.05)	NS	NS	11.57	22.06	0.74

*RDF = Recommended dose of fertilizer
*NS = Non-significant

Table 2: Effect of integrated nutrient management on dry matter accumulation of mustard (*Brassica juncea* L.).

Treatment	Dry matter accumulation (g m^{-1} row length)		
	At 60 DAS	At 90 DAS	At harvest
T_0 – Control	63.91	127.13	151.57
T_1 - 75% RDF	78.84	152.70	183.81
T_2 - 100% RDF	91.26	173.97	209.66
T_3 - Vermicompost (2 t ha^{-1})	77.71	150.94	180.91
T_4 - FYM 10 t ha^{-1} + *Azotobacter*	76.87	149.40	177.22
T_5 - 75% RDF + Vermicompost (2 t ha^{-1}) + *Azotobacter*	93.55	177.57	213.09
T_6 - 100% RDF + Vermicompost (2 t ha^{-1}) + *Azotobacter*	95.58	180.97	217.76
T_7 - 75% RDF + FYM 10 t ha^{-1} + *Azotobacter*	92.63	175.10	211.12
T_8 - 100% RDF + FYM 10 t ha^{-1} + *Azotobacter*	94.40	178.83	215.28
SEm$\pm$	3.77	6.78	8.13
CD (P = 0.05)	11.29	20.32	24.37

*RDF = Recommended dose of fertilizer
*NS = Non-significant

Table 3: Effect of integrated nutrient management on nutrient content of mustard (*Brassica juncea* L.).

Treatments	Nutrient content (%)					
	Nitrogen content		Phosphorus content		Potassium content	
	Seed	Stover	Seed	Stover	Seed	Stover
T_0 – Control	2.29	0.391	0.372	0.208	0.445	1.09
T_1 - 75% RDF	2.71	0.484	0.455	0.248	0.529	1.26
T_2 - 100% RDF	3.00	0.576	0.515	0.280	0.593	1.40
T_3 - Vermicompost (2 t ha^{-1})	2.66	0.476	0.448	0.241	0.519	1.24
T_4 - FYM 10 t ha^{-1} + *Azotobacter*	2.62	0.468	0.447	0.237	0.511	1.22
T_5 - 75% RDF + Vermicompost (2 t ha^{-1}) + *Azotobacter*	3.08	0.585	0.521	0.287	0.604	1.43
T_6 - 100% RDF + Vermicompost (2 t ha^{-1}) + *Azotobacter*	3.14	0.594	0.530	0.295	0.615	1.47
T_7 - 75% RDF + FYM 10 t ha^{-1} + *Azotobacter*	3.04	0.582	0.517	0.284	0.597	1.42
T_8 - 100% RDF + FYM 10 t ha^{-1} + *Azotobacter*	3.11	0.589	0.525	0.291	0.609	1.45
SEm$\pm$	0.08	0.015	0.013	0.007	0.02	0.04
CD (P = 0.05)	0.24	0.046	0.040	0.022	0.05	0.11

*RDF = Recommended dose of fertilizer
*NS = Non-significant

Table 4: Effect of integrated nutrient management on nutrient uptake of mustard (*Brassica juncea* L.)

Treatments	Nutrient uptake (kg ha^{-1})					
	Nitrogen uptake		Phosphorus uptake		Potassium uptake	
	Seed	Stover	Seed	Stover	Seed	Stover
T_0 – Control	26.38	9.10	4.29	4.88	5.14	25.51
T_1 - 75% RDF	40.70	14.63	6.83	7.44	7.89	37.84
T_2 - 100% RDF	53.27	20.30	9.13	9.84	10.51	49.15
T_3 - Vermicompost (2 t ha^{-1})	39.09	13.96	6.59	7.11	7.59	36.48
T_4 - FYM 10 t ha^{-1} + *Azotobacter*	37.63	13.30	6.44	6.75	7.38	34.84
T_5 - 75% RDF + Vermicompost (2 t ha^{-1}) + *Azotobacter*	55.25	20.97	9.36	10.26	10.83	51.31
T_6 - 100% RDF + Vermicompost (2 t ha^{-1}) + *Azotobacter*	57.43	21.85	9.70	10.80	11.23	53.80
T_7 - 75% RDF + FYM 10 t ha^{-1} + *Azotobacter*	54.16	20.65	9.23	10.07	10.64	50.58
T_8 - 100% RDF + FYM 10 t ha^{-1} + *Azotobacter*	56.27	21.35	9.51	10.57	11.06	52.54
SEm$\pm$	2.27	0.97	0.47	0.40	0.42	1.80
CD (P = 0.05)	6.82	2.91	1.41	1.20	1.25	5.39

RDF = Recommended dose of fertilizer
*NS = Non-significant

Table 5: Effect of integrated nutrient management on oil content and oil yield of mustard (*Brassica juncea* L.).

Treatments	Oil content (%)	Oil yield (kg ha^{-1})
T_0 – Control	28.27	328
T_1 - 75% RDF	35.49	530
T_2 - 100% RDF	35.88	635
T_3 - Vermicompost (2 t ha^{-1})	32.34	477
T_4 - FYM 10 t ha^{-1} + *Azotobacter*	31.68	457
T_5 - 75% RDF + Vermicompost (2 t ha^{-1}) + *Azotobacter*	36.55	656
T_6 - 100% RDF + Vermicompost (2 t ha^{-1}) + *Azotobacter*	37.31	683
T_7 - 75% RDF + FYM 10 t ha^{-1} + *Azotobacter*	36.35	648
T_8 - 100% RDF + FYM 10 t ha^{-1} + *Azotobacter*	36.98	671
SEm$\pm$	0.82	29.64
CD (P = 0.05)	2.47	88.87

*RDF = Recommended dose of fertilizer
*NS = Non-significant

The integrated nutrient application increased nutrient availability (N, P, and K) in mustard, which may be attributed to accelerated microbial nitrogen fixation as well as improved soil physical properties and root development. The observation made by Shukla *et al*. (2002), Tripathi *et al*. (2010), Khare *et al.* (2023) and Kantwa *et al*. (2023) are very similar to those of these studies.

C. Impact of INM on quality

A significant impact on the quality of mustard was seen when inorganic fertilisers were applied alongside organic manure and biofertilizers. The application of 100 percent RDF + vermicompost (2 t ha^{-1}) + azotobacter (T6) resulted in the highest oil content (37.31 percent) and oil yield (683 kg ha^{-1}) (Table 5). Oil yield and content may also significantly increase due to synthesis of fatty acids by converting acetyl Co-A to malonyl Co-A in the presence of ATP and phosphate (Bonner and Varner, 1995). Furthermore, the development of more lecithin may be linked to the higher oil content. In the mustard crop, similar results were reported by Kumar *et al*. (2018b), Sahoo *et al*. (2018), Bijarnia *et al*. (2017), Dubey *et al*. (2021), Khare *et al.* (2023) and Gupta *et al*. (2023).

CONCLUSION

According to the study's findings, different sources of nutrient treatments significantly improved the growth, yield and quality of mustard. It can be concluded that the application of synthetic fertilizer in combination with organic manures and biofertilizer was the most suitable for mustard.

FUTURE SCOPE

The fundamental principle of INM is to maximise the use of all available nutrient sources in order to improve economic and environmental sustainability, as well as the security and quality of the food supply. Chemical fertilisers, nutrients supplied by soil and atmospheric deposition, nutrients released by soil biological activity, and nutrients recycled from crop residues, organic manures, and urban and industrial sources are all available to crops. As a result, INM will play a critical role in environmentally and economically sustainable agricultural production.

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